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ELECTRICAL TECHNOLOGY

GRADE 12 REVISION BOOKLET

TERM 3

2023

The aim of this booklet is to help you preparing yourself better for the final year end exams by revising critical content and skills covered in Grade 12. The booklet will also focus on typical mistakes learners make when answering questions. It will try and guide you to obtain maximum marks for questions asked in the NSC exams.

This revision covers the following topic

- Programmable logic Controllers

It is important to prepare yourself by practice answering questions from past papers

You can download papers from:

[https://www.education.gov.za/Curriculum/NationalSeniorCertificate\(NSC\)Examinations/NSCPastExaminationpapers.aspx](https://www.education.gov.za/Curriculum/NationalSeniorCertificate(NSC)Examinations/NSCPastExaminationpapers.aspx)

There are also lessons on various grade 12 topics on the WCED e-Portal

(<https://wcedportal.co.za/>)

GENERAL

Structure of the NSC Exam paper and Important point to remember:

- The paper consists of **SEVEN** compulsory questions, **ONE** multiple choice question covering all the topics proportionately and **SIX** further questions covering the six topics in the syllabus.
- The multiple-choice questions will be of the type where a question is asked, and options is given where you must select the correct option.
- The weighting of the questions is as per the table below.
- It is important to remember that the paper is out of 200 MARKS, and the time given is 3 HOURS ie 200 marks = 180 minutes.
- It is important to ensure that you manage your time properly when writing any test or exam. You don't want to run out of time because of bad time management.
- The following rough guide will help you manage your time a bit better. 1 Mark = 1 Minute (If a question is out of 10 marks, do not spend more than 10 minutes on that question)
- Try and start with the easiest question and work your way up to the more difficult questions.
- All questions and sub questions must be kept together. DO NOT MIX QUESTIONS
- Draw a line after each completed question.
- It is important that you read all instructions slowly before you start answering any question.
- Also, please note that you must receive a formula sheet with every test or exam you write, covering at least the topics of the test or exam.
- The questions are asked in such a way that it will differentiate in terms of subject knowledge. It might start with an easy question and end off with more challenging question in the different questions per topic.

Final Examination Weighting in Power systems:

Topic	Grade 12	
	Percentage	Marks (+/- 4)
Multiple Choice	7.5%	15
Occupational Health and Safety	5%	10
RLC	17.5%	35
Three Phase Generation	17.5%	35
Three Phase Transformers	15%	30
Motors and controls	17.5%	35
Programmable Logic Controllers	20%	40
Total	100%	200 Marks

BASIC SKILLS LINKED TO THE SUBJECT:

The following skills are measured in the paper:

- Ability to follow instructions • Identifying labels/labelling/making drawings/diagrams/schematic representations
- Plotting and interpretation of graphs/data
- Working out and interpreting calculations
- Organising/Recording and categorising data
- Extraction and/or manipulation and/or evaluation of data

It is important that you have your own Scientific Calculator, and that you know how to use it. NEVER BORROW A CALCULATOR FOR ANY EXAMINATION!!!!!!

TOPIC

NB!!!! The mark allocation will indicate how you much information you are required to provide in your responses/ answers to questions.

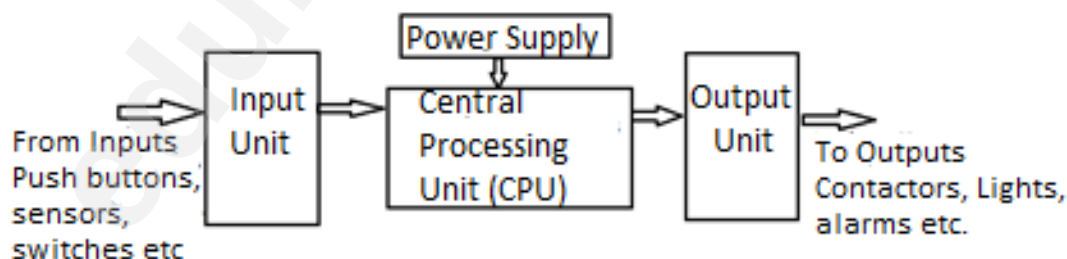
This section of the work count 30% (60 marks) of the total marks of the paper, make sure you know this work thoroughly

TOPIC 1: Programmable logic Controllers (PLC)

A PLC is simply an Industrial computer that is programmed to perform specific tasks in a specific order. It takes instructions from externally connected inputs (switched, pressure pads, sensors etc) to activate a range of output devices. (Motors, contactors, lights etc) This topic is all about understanding the important concepts regarding programmable Logic controllers as well as the drawing of ladder diagrams and block diagrams.

Variable speed drives is a new concept so more attentions must be given to the understanding of concepts related to it. Variable speed drives is about controlling the speed of AC motors by varying the frequency supplied by the motor.

The block diagram of the PLC and the function of each components is very important.



CPU – This is the ‘brains’ of the PLC. The processor is the unit that is responsible for the processing of all arithmetic operations, logic operators, storage of information, computer interface, local area network etc

Input unit – convert signals from discrete or analog input field devices to logic levels acceptable to PLC’s processor. Inputs can be switches and sensors etc.

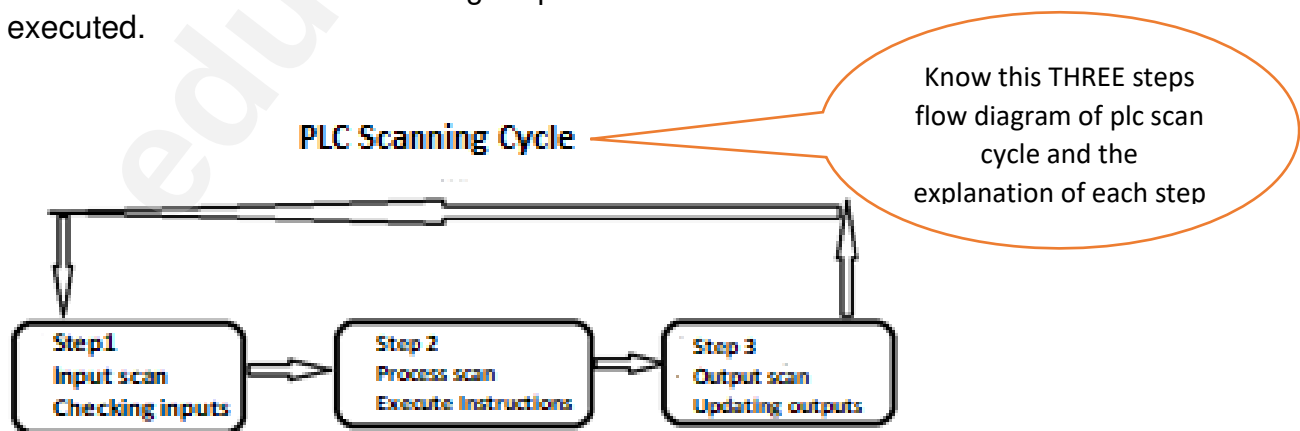
Output unit - converts signal from the processor to levels capable of driving the connected discrete or analog output field devices. Outputs control other devices, such as motors, pumps, solenoid valves, and lights.

Power Supply -The power supply provides the voltages needed to run the all the PLC components. Most PLC controllers work either at 24V DC or 240V AC.

Comparison between Relay logic and the PLC

Relay	PLC
Large complicated system that takes up lots of space	Very compact solid-state device that is relatively small
Use much more energy than PLC system	Use about 1/10th the amount of energy of relay system
Limited mechanical life and more maintenance	A solid-state device with a very long life and less maintenance
More expensive than PLC system – the more the relays the greater the cost	Cost much less compared to relay logic system (onetime investment)
Mechanical breakdowns can occur at any time- many moving parts	More reliable because of no moving parts
Difficult to update or modify an existing program	Very flexible because it is easy to change or modify a program
Response time slower than that of the PLC	Fast response time- can process thousands of items per second

You must also know the scanning sequence of the PLC – how each instruction is executed.



The scan cycle:

1. **Input scan** - the PLC reads and sends inputs to the input table. It determines whether an instruction is low (0) or high (1).
2. **Process scan** - The PLB executes the step-by-step instructions. Rungs are processed from top to bottom, sequentially processed by the Central Processing Unit (CPU).
3. **Output scan** - the PLB now activates each output according to the output table's memory viz. On (1) or Off (0).
4. **Steps 1-3 are repeated.**

The following safety aspects must be considered when working with a PLC

- A PLC must have a short earth connection with a minimum thickness of 2mm².
- There must be a main switch to turn off the circuit.
- PLC must have input and output fuse.
- Contactors must be installed securely.
- PLB must be isolated.

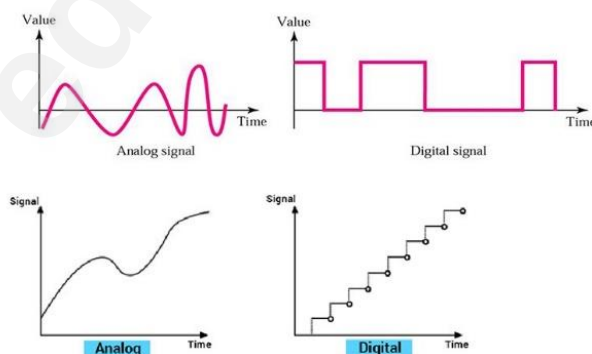
Difference between analogue and digital signals:

PLC's are electronic digital devices that only understands digital electrical signals. (in the form of '1's' and '0's') Analogue signals from various types of sensors must therefore first be converted to a digital signal before the PLC will be able to understand it.

Analogue signals: these are signals that is continually varying and comes from sensors measuring pressure, temperature, water levels etc.

Digital signals: these are signals in the form of "ON" or "OFF" or "HIGH" or "LOW"

PLC's are devices that only understands digital electrical signals.



Different input devices

The PLC will react to discrete switched or push button switches which provide electrical ON or OFF inputs to the PLC, or inputs from analogue device /sensors such as movement, temperature, levels, pressure sensors etc. Please note information from analogue sensors must first be converted to digital format before the PLC can process it

Do not confuse a sensor with a transducer, they are not the same

Different types of sensors

It is important that you know the different types of input sensors and their applications

*The main difference between a sensor and a transducer is that a sensor senses the difference or change in the environment they are exposed to and gives an output in the same format where as **a transducer takes a measurement in one form and converts it to another for example, a measurement which is not electrical and converts it into an electrical signal.***

Proximity sensors: they detect the presence of an object using light, sound or electromagnetic fields. There are THREE types of proximity sensors:

- Inductive proximity sensor
- Capacitive proximity sensor
- Ultrasonic proximity sensor

Temperature sensors: You get a variety of temperature sensors, but they all measure the temperature by sensing a change in the physical state of materials.

Light sensors: These are devices which detect light. Light sensors have many applications from automatic door openers to modern to electronics including TV's and computers.

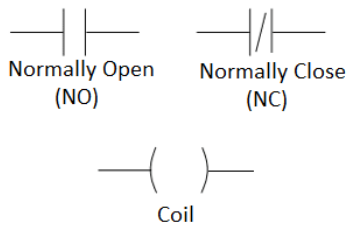
Level sensors: They are mainly used to monitor and detect levels of liquids in tanks, rivers and dams.

Overload sensors (strain gauge): This is an electro-mechanical device that translate a mechanical force into an electrical signal. It works by sensing the force of the load.

What is a Contactor/ Relay?

It is a heavy current relay that is very sturdy and capable of handling high current of large motors. A contactor's contacts can be in two states viz. Normally open and normally closed.

Basic ladder logic instructions



Timers

A timer is used to delay the output of a PLC output.

A timer can be an **ON delay** or an **OFF delay**.

ON delay: The timer's contacts would not operate until the pre-set delay time has passed, after it has first been energized in the logic sequence.

OFF Delay: Timer's contacts will immediately operate and remain in this active state once energized. Its contacts will only deactivate and open after the preset time has passed.

Typical question:

Differentiate between an ON-delay timer contact and an OFF-delay timer contact. (4)

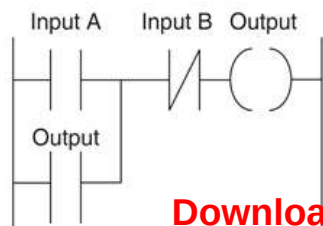
An ON-delay timer contact would not operate ✓ until a pre-set delay time has passed, after ✓ it has first been energised.

An OFF-delay timer contact will immediately operate ✓ and remain in this active state once energized. Its contacts will only deactivate and open after the pre-set time has passed, ✓ after it has been de-energised.

Latching Concepts:

A latch allows for an event that is turned on to stay on until the circuit is disconnected again.

In the figure below, input A is latched with a holding contact which is connected in parallel with the input. As soon as input A is activated, the holding contact will be activated and the input can be released. The output will be delivered until the NC Input B is activated to break the circuit.



Know this concept, it is very important

Markers / Flags: (memory elements)

Markers are virtual memory elements that are programmed to store data and then act as a relay.

A flag is a notice added by the logic designer to indicate when an instruction was started or executed.

Converting hard wiring to ladder logic:

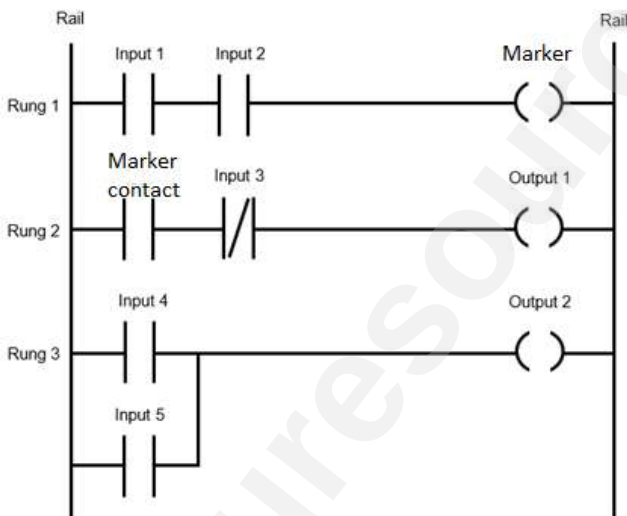
A ladder logic diagram consists of two vertical lines known as power tracks or ladders, and horizontal lines known as rungs.

Each rung represents a step in the control process.

Each rung starts at the left live track and will end with one output at the right neutral track.

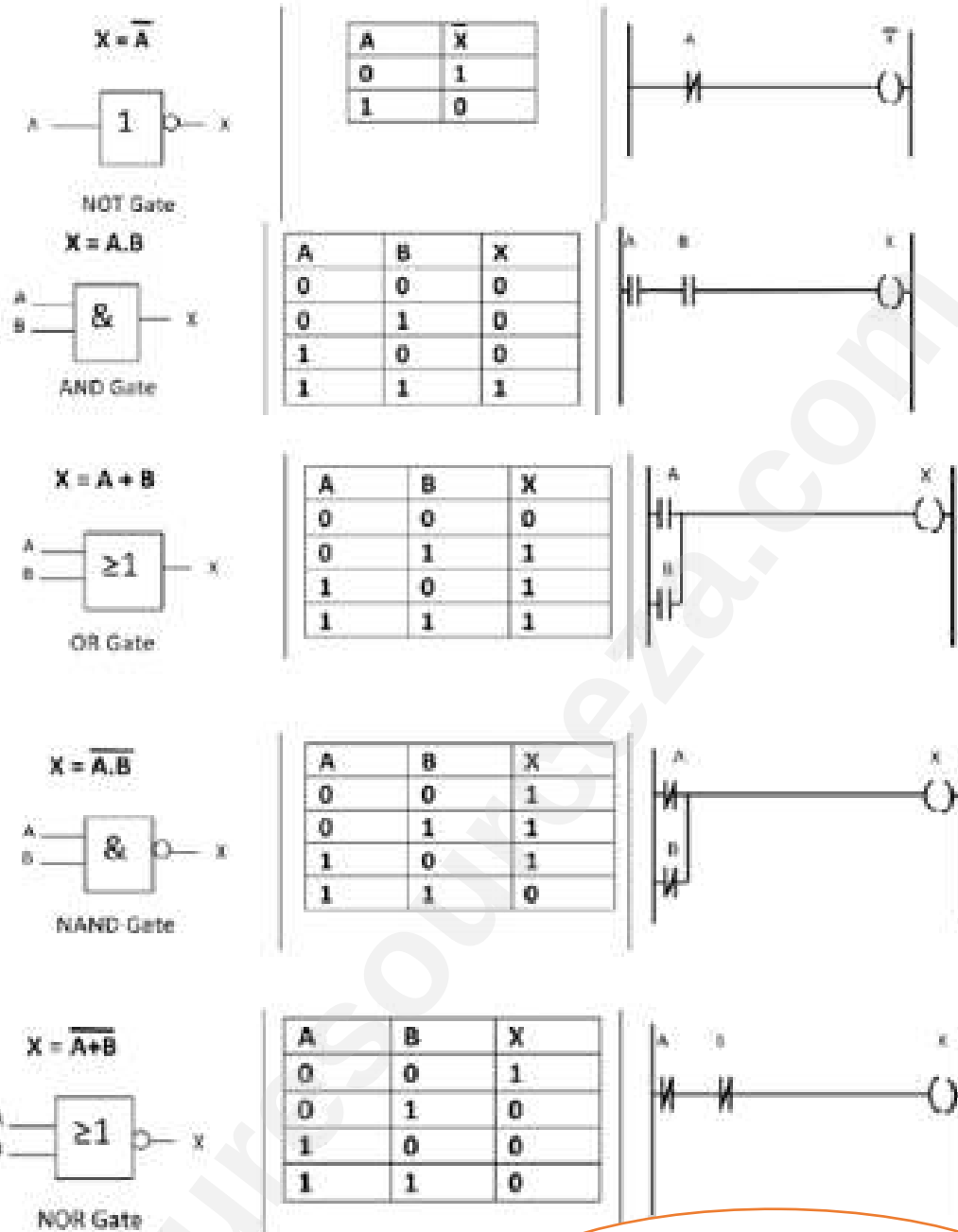
A ladder logic diagram is read from left to right and from top to bottom.

From the first rung to the last rung, is called the PLC cycle.



Logic gates: we will briefly be looking at basic Logic gates, truth tables and ladder logic equivalents for AND, OR, NAND, NOT and NOR gates

Know these logic gates:
symbols, truth tables and
ladder diagrams



Typical Questions:

Always read the questions thoroughly before you answer it. Look at mark allocation to determine the number of facts that must be given

1. State THREE disadvantages of hard wiring. (3)

Requires regular maintenance. ✓

It takes time to locate a fault. ✓

It takes longer to re-wire the system when compared to the reprogramming of the PLC. ✓

2. Name the THREE steps that a PLC must undergo to complete one programmed scan cycle. (3)

Input scan/input module .✓(checks input device state)
Process ✓(complete instruction)
Output module ✓(update)

3. With reference to analogue and digital inputs, give THREE examples of analogue input devices. (3)

Light sensor. ✓
Level sensor. ✓
Overload sensor. ✓
Temperature sensor.

Answers of descriptive nature must be concise and to the point

4. State the purpose of the timer function. (2)

The purpose of the timer function is to activate or deactivate a device ✓after or before a pre-set interval of time. ✓

OR

The purpose of the timer function is to run an operation for a predetermined period.

5. Explain the latching concept with reference to retaining circuits. (3)

The concept of latching makes it possible for circuit to be triggered 'on'✓and remain 'on'✓regardless of whether the activating trigger has been removed.✓

6. State when a marker/flag function is used in the PLC. (2)

A marker or a flag function is used in the PLC to connect the end of a rung ✓to the beginning of the next rung ✓of a PLC program.

OR

A marker or a flag function is used in the PLC to transfer digital information to another part of the program.

7. Explain the programmed scan cycle under the following headings:

7.1 Input scan (3)

7.2 Process scan (3)

7.3 Output scan (2)

7.1 The input scan sequentially scan all its input terminals✓ to see if either their input conditions are ON/OFF✓and read each condition into the input memory✓

7.2 After the PLC reads the ON/OFF conditions of every input in the input memory, it will start to execute ✓ every instruction in the program in a sequentially order. ✓ The execution result ON/OFF of

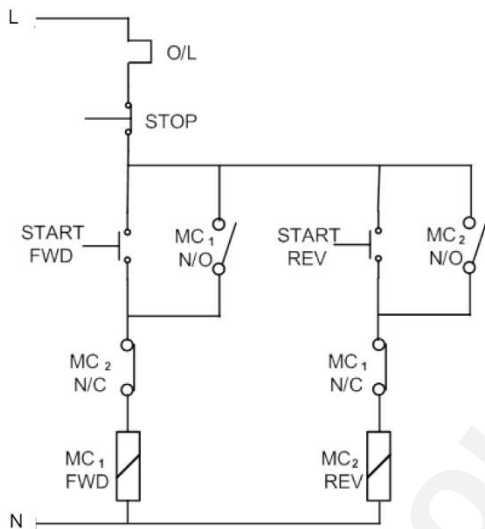
every output coil will be stored in order into the memory.✓

7.3 Output scan activates each output according to the conditions of the output stored in its memory ✓to turn the appropriate load devices as per the conditions of the output.✓

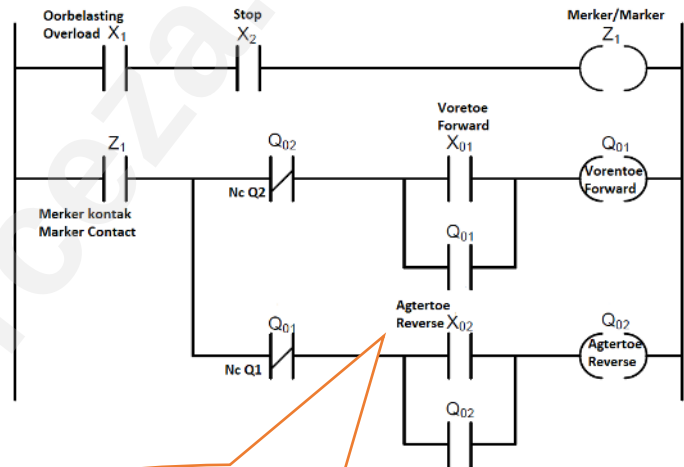
Applications of PLCs as motor starter:

Forward/reverse Starter -

Circuit diagram (F/R starter)



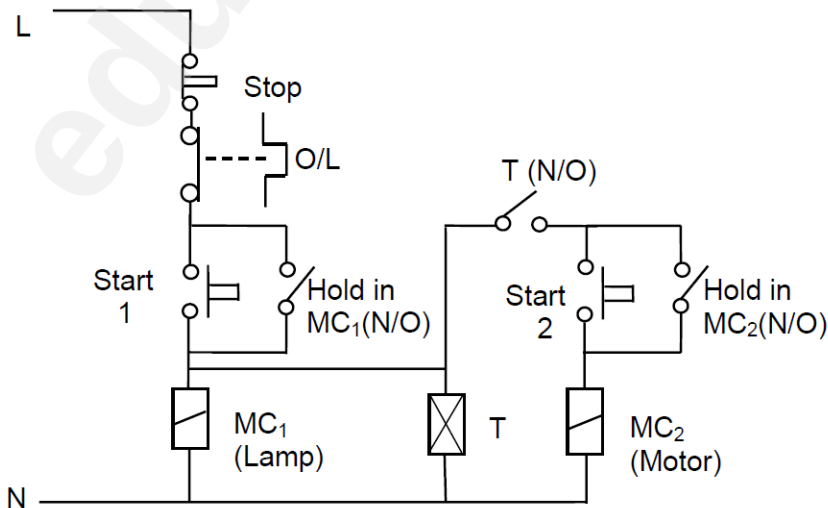
Ladder diagram of a F/R starter



Please ensure that you label you ladder diagram correctly

Typical Questions

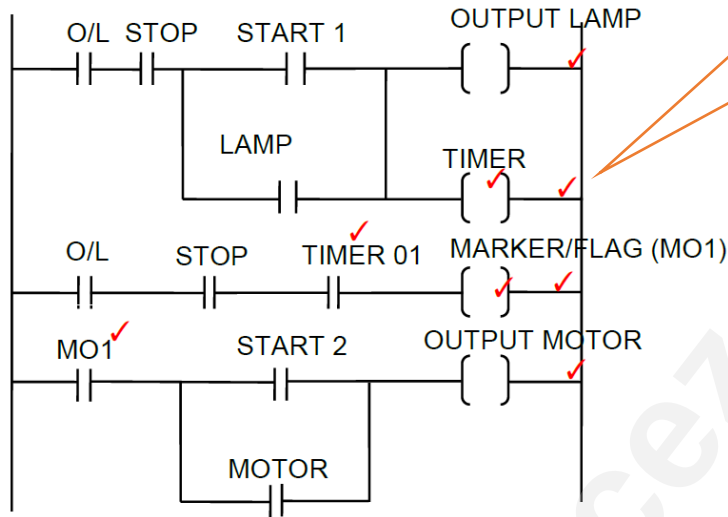
1. Refer to the circuit diagram below and answer the questions that follow.



Identify the circuit above (2)

Draw the PLC ladder logic diagram that would execute the relay control circuit.
Your diagram must include a marker or a flag function. (8)

Automatic ✓sequence starter✓



Note

- You may use inverse functions (simulating real world NO and NC switches) in the ladder circuit.
- Please check that you label the ladder diagram in accordance to the circuit diagram.

2. Refer to the figure below and answer the questions that follow.

2.1 Identify the control circuit in the figure below (1)

2.2. Draw a ladder logic diagram that executes the same function as the one in the figure below. (13)

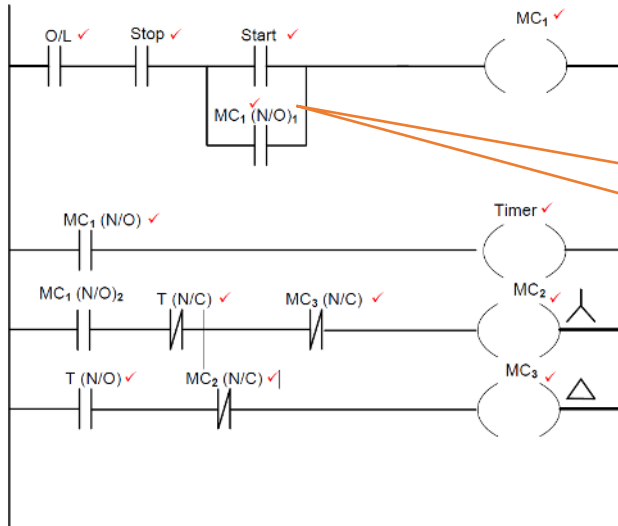
2.3 State the function of the MC₁/NO₁ as used in ladder logic circuits. (2)

2.4 State why the N/C contact of MC₃ is connected in series with the star contactor. (2)

2.1 Automatic star delta starter. ✓

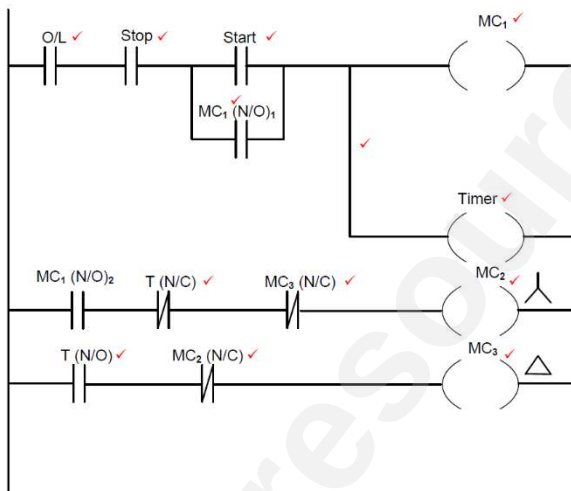
Star delta starter

2.2



Please ensure that you label your ladder diagram correctly

OR ALTERNATIVELY



Latching is important and you must know this concept

2.3 The function of the MC₁/NO₁ in ladder logic control circuit is to Latch the circuit✓ and keep the program running even after the start button is released.✓

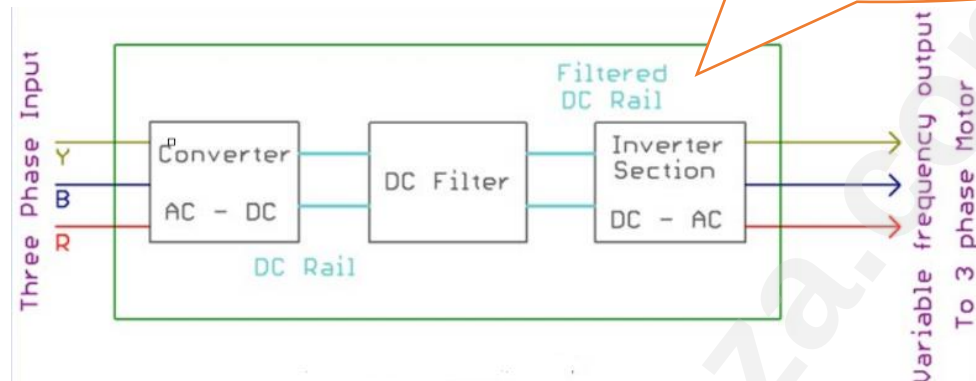
2.4 The purpose of MC₃ NC is to interlock✓ and prevents ✓ MC₂ from engaging when MC₃ is engaged in delta.

The concept of interlocking is very important, and you need to understand it properly

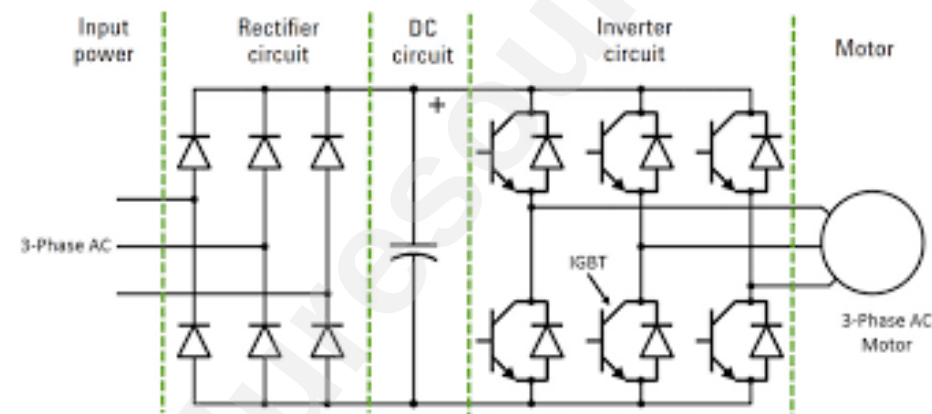
The Variable Speed Drive (VSD): Also, sometimes called Variable Frequency Control VFC

A VSD regulates the rotational speed of an alternating current motor by changing the supply frequency to the motor.

Block diagram of a VSD:



Circuit diagram of VSD



Three basic steps of a VSD:

Step 1 - AC supply voltage is converted to DC by means of A rectifier / diode bridge. (Three pairs of rectifying diodes)

Step 2 - The AC ripple voltage is smoothed out by using a filter capacitor to obtain a pure DC voltage.

Step 3 - The DC voltage is changed back to AC voltage at a changed frequency. The frequency is changed by the bipolar transistors with insulated gates (IGBTs). This process is called pulse width modulation (PWM)

Two methods of speed control:

1. V / Hz drive is an application where the supply voltage is directly related to the frequency.
2. The Vector driver has a mathematical model of the drive-in software and by the measuring the current vectors in relation to the supply voltage, they can maintain a constant field at all frequencies below the line frequency.

Types of motors that use with VSD:

- AC asynchronous squirrel cage motor for industrial applications.
- AC asynchronous wound rotor motor, where the load requires high starting torque.
- AC synchronous motor with permanent magnet stator
- AC synchronous motor, with brushes and brushless.

This concept is important, know it

Regenerative braking:

This process happens when the load on the motor rotates faster than the motor. Like an elevator moving downwards, it will be held back by regenerative braking.

The motor then acts as a generator that converts mechanical power into electric power. The system must get rid of the regenerative energy and it is then stored in the VSD's DC capacitors. To prevent damage to the capacitors, a breaking resistor' is connected to the circuit to dissipate the regenerative energy. The resistor becomes hot and dissipate the heat energy.

Other methods of regenerative breaking are:

- Electrical locomotives going downhill transfer regenerative energy back into the system.
- Electrical vehicles make use of regenerative breaking in city traffic to recharge batteries.
- Lifts and cranes are also places where regenerative breaking is applied.

Basic applications of VSDs:

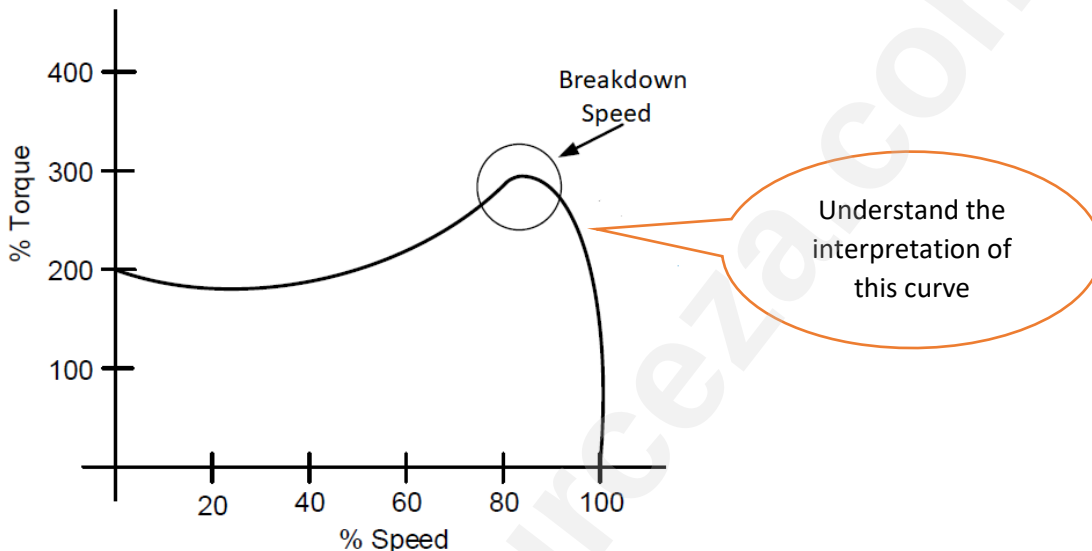
- Air conditioners
- Water pumps
- Exhaust gas extractors
- Fans

Start-up and run profiles

- Adjustable speed drives accelerate a motor from start to a region above the breakdown speed as indicated on the curve below
- The normal limits of fix frequency, fixed voltage, fixed starting frequency and acceleration do not apply.

- The starting current and torque are limited by the overload capabilities of the VSD and not limited by the per unit slip characteristics of the motor.
- The VSD can be designed to match the motor and load in such a way that results in the applicable torque characteristic as in the figure below.

Torque/Speed Curve



Typical Questions

1. Name THREE types of motors used with variable speed drives (VSD). (3)
 2. Explain the purpose of the braking resistor with reference to regenerative braking (2)
 3. Explain the function of the VSD when used in motors. (2)
 4. State THREE basic applications of the variable speed drive (VSD). (3)
 5. Describe how the VSD controls the speed of motors under the following Sub-circuits
- 5.1 Diode bridge rectifier (2)
 - 5.2 Filtering circuit (3)
 - 5.3 Inverting circuit (3)

Typical answers

1. Induction motors. ✓
AC synchronous moto. ✓
AC asynchronous motors. ✓
DC motors ✓
2. The purpose of the braking resistor is to stop or slow down the motor through absorption of excess energy ✓ and converting excess energy to heat while

in motion by transforming kinetic energy back into electrical energy ✓ through the process of regenerative braking.

3. The function of the VSD is to control the speed of an AC motor ✓ by varying the frequency of the voltage supplied ✓ to the motor.
The function of the VSD is to control the speed of a DC motor by varying the voltage supplied to the motor

- 4 VSD is applied in:
Water pumping system ✓
Exhaust air system ✓
Extracting dust ✓
Heating system for air and liquid
Variable air volume air conditioning system

5. 5.1 Diode bridge rectifier convert AC supply ✓ voltage to a DC voltage ✓

- 5.2 Filtering circuit smooth the AC ripple ✓ to ensure pure DC ✓ voltage on the rail ✓

- 5.3 The DC voltage is then inverted back into an AC voltage ✓ but at a different frequency ✓ by switching the insulated gate bipolar transistor ON and OFF ✓